Geoscientific
Model Development
Discussions

Interactive comment on "The Environment and Climate Change Canada Carbon Assimilation System (EC-CAS v1.0): demonstration with simulated CO observations" *by* Vikram Khade et al.

Anonymous Referee #2

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General comments:

The paper discusses first developments towards an assimilation system for optimizing greenhouse gas concentrations to analyze the carbon cycle globally, but also for Canada. The new developments comprise an extension of the Environment and Climate Change Canada's operationally used Ensemble Kalman Filter to CO observations. The new systems behavior is analyzed using identical twin experiments.
The paper is of general concern for GMD but lack of clarity in the argumentation. While the system aims at analyzing the carbon cycle on a global scale, but also for Canada,

the analyzed time interval from 27 December 2014 to 28 February 2015 is sub-optimal. The papers Fig. 2 suggests that CO fluxes for January 2015 are negligible for Northern Canada. The identical twin experiments should be conducted in the wild fire season to proof the systems ability of analyzing the CO state appropriately even in challenging wild fire episodes. While assimilating synthetic CO observations, the paper claims at several points to be a greenhouse gas assimilation system and that the model state to be optimized is augmented by CO, CO2, and CH4. A clear distinction between future efforts towards the full system, covering also CO2 and CH4, and the current state of the system is not given. In the introduction, it is not made clear how CO assimilation can also improve the concentrations of greenhouse gases. A paragraph about this aspect would be appreciated.

Specific comments:

- generally, the Grammar of the paper, especially the use of commas and articles, should be reviewed

- line 17: replace "GHG" by "greenhouse gases (GHG)"

- line 24: change "2015 or 2016" to "2015 and 2016"

- line 24-25: add a reference for the statement on NIR estimates of anthropogenic CO in Canada

- line 29-34: The claim is not clear. If wild fires are important for the carbon cycle, why not conducting the experiments in the wild fire season. Further, EC-CAS v1.0 does not assimilate CO2 and CH4. Thus, the paper should not claim that EC-CAS does include CO2 and CH4 in the assimilation process.

- line 81: change "GHG and flux estimation" to "CO estimation". In section 2.4 only consider CO estimation in, not GHG. Further, as this is not the purpose of this paper, do not explain details about flux estimation. This should be attributed to the respective paper

- line 95: please add: . . . at every grid point "as well as an perturbed CO emission fluxes."

- line 99 -101: There is no need for repeating the outline of the section. Please remove

- line 107: ". . . and the same lid of 0.1° hPa." Please correct the unit. Do not use "lid", rather use "model top" or equivalent.

- line 116: start a new paragraph

- line 121: replace "This is because. . . is used for..." by "Thus, . . . can be used for"

- line 122: replace: ". . . with an EnKF so the computational expense of complete chemistry is prohibitive and difficult. . ." by "with an EnKF. The computational expense of the complete chemistry would be prohibitive and difficult. . ."

- line 134: add a reference for the statement made in the parenthesis

- line 188, Equation 4: An information about the form of the observation operator, especially for MOPITT-like observations, is missing in the manuscript. Please also consider talking about MOPITT-like observations, rather than MOPITT observations. Further, what is the difference between ρ_m and ρ_o?

- line 190: replace "when" by "if"

- line 193: replace "For example when the both the row and column. . ." by "For example, if both, the row and column. . ."

- line 194: replace "that element" by "the respective element"

- line 200-201: This sentence needs to be linked to the rest of the paragraph

- line 213: a table of parameters and the value range would be appreciated

- line 235: Do not start a new paragraph

- line 237-238: Do not include the outline of the next paragraphs

- line 248-250: replace ". . . one each for January and February 2015" by "one for January and February 2015, respectively". Further, rephrase to following phrase.

- line 303: check the line breaking

- line 305: replace "This control experiment assimilates. . ." by "The control experiment (EXP_CNTRL) assimilates. . . "

- line 314: . . . results of assimilating the meteorological variables.

- line 316: the aspect of area-weighted statistics is not made clear. Please provide a description of the weighting procedure.

- line 320: A reference for the climatological values of the temperature uncertainty is missing"

- line 331: . . . RMSE (Figure 6c) and its comparable strength is encouraging. . .

- line 334: . . . over the analysis period is shown by. . .

- line 337-339: Do not include an outline of the next sections

- line 340 (section 4.2): This paragraph lacks on focus. The spatial correlation on two specific days is given. How does this supports the analysis in the subsequent sections? No investigation about the influence of different localization radii is done. The influence of the localization radius on the assimilation results is not investigated. Please consider removing this section or expand it to a more detailed investigation on the localization radii.

- line 371 (section 4.3): throughout this section please be careful in the description of the results. E. g., refer to HYPNET observations but to the EXP_HYP experiment. The same for all other experiments/observation types. This has been mixed up several times.

- line 395: The mean relative benefit. . .

- line 397 – 402: Please make the description more specific by, e. g., including specific values of the benefit.

- line 400: By comparing Fig. 9a and 9b, it is evident that the benefit due to the assimilation of HYPNET observation and MOPITT-like retrievals is also comparable in the column mean, . . .

- line 403: Fig. 10a shows the benefit of the EXP_GAW experiment.

- line 407: replace: "Though USA does not have any stations in this experiment. . ." by "Even though no stations are located in the USA in this experiment, . . ."

- line 414: Fig. 10a shows that assimilation of GAW observations results in . . .

- line 448: please use km as unit for consistency

- line 450: . . . ECCC observations compared to HYPNET observations, which are located at about 1 km.

- Description of Fig. 11: This description is tedious and have to be condensed. For the results of this analysis, the precision of the given height of the observations is irrelevant. Please consider summarizing the mean height information of the different 0station types ad experiments in a table

- line 473: no greenhouse gas assimilation system was presented. Please be more precise

- line 479: .. due to the assimilation of observed CO is proportional...

- line 480: Another factor, which controls the pattern of the benefit, is the location of observations.

- line 482: . . . 2000 km, which is the localization radius used in these experiments.

- line 483: . . . lowermost 500 m than observations at 1 km.

- line 486: replace "Pacific" by "Atlantic"

- Figure 1: change "prescribed CO fluxes" to "ensemble of prescribed CO fluxes"

- Figs. 4 and 5: please increase the resolution of the figures title and axes annotations

- Figure 5: please change the x-axis annotations to dates, same for Fig. 7

- Figure 6: The vertical range of the averaged column (0-5km) is not consistent with other figures, where the range is 0-10 km. Please verify. Further: . . . (d) RMSE of the EXP_HYP experiment.

- Figure 8: Spatial correlation of CO between Toronto. . .